学 位 論 文 要 旨

Study on Steam Injection Drying of Laser Incised Lumber
レーザインサイジング材の蒸気噴射乾燥に関する研究

環境資源共生科学専攻　森林資源物質科学大講座
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Wood drying is one of the most important processes to enhance overall properties of wood and wood products and requires substantial energy and time. A faster and more efficient process to dry wood to acceptable levels will improve productivity of wood industry. A unique drying technology of laser incising and combination of steam injection drying and microwave irradiation was proposed to increase drying rate and quality of lumber. The objective of this study was to investigate the effect of CO_2 laser incising on drying rate and quality of Japanese cedar and Japanese larch lumber when laser incised lumber was dried by steam injection and microwave irradiation.

To investigate the effect of laser incising on drying characteristics of Japanese cedar lumber under five drying methods, the squares (120 mm x 120 mm) of Japanese cedar lumber with length of 650 mm were used. A half of specimens were incised by CO_2 laser with incising density of 2,500 holes/m^2. Five types of drying methods were employed, that is, steam injection drying, microwave drying, and three combinations of microwave heating and steam injection drying. Steam injection drying was conducted by injecting superheated steam of 120°C through a perforated platen heated to 140°C of an injection press. Microwave drying was conducted with the power of 3 kW at frequency of 2.45 GHz. The results indicated that incised holes help heat spread across the specimen, and thus the temperature raised at a speed of up to three-folds compared to that of no-incised one. Ruptures of pits and pit membranes were found and were suggested to improve permeability of the specimens for those five drying methods. Incised specimens dried by a combination of microwave heating for one hour and steam injection showed the highest drying rate (5.3 %/hour), which was five-folds or more faster compared to other drying methods applied in Japanese cedar lumber. Incising and microwave heating enhanced overall drying of the lumber in terms of more uniform distribution of moisture content and reducing surface and internal checks.

To explore the effect of laser incising density, six boxed-heart Japanese larch lumbers with a dimension of 120 x 120 x 650 mm were used. Specimens were incised with three types of incising densities, which were 0 (no-incised), 2,500 holes/m^2 and 7,500 holes/m^2. Drying process were carried out by steam injection drying, microwave drying, and combination of microwave heating one hour and steam injection drying. Steam injection drying was conducted by injecting superheated steam with temperature of 110°C through the perforated platen with temperature of 120°C. Pressure of drying chamber was kept on 50 kPa above the atmospheric one. Microwave irradiation was done by using microwave operating frequency at 2.45 GHz and specific power at 4.5 kW. The results confirmed that increasing incising density improved significantly the drying rate of the samples. Laser incising density of 7,500 holes/m^2 could accelerate the drying speed of the specimens up to five-fold compared to that of no-incised ones. Microwave heating for 1 h and steam injection drying was also the best method to dry laser incised Japanese larch to final m.c. of 12%. Laser incising and microwave heating also contributed on creating more uniform moisture distribution of Japanese larch lumber than that dried by steam injection drying. Though the increase in laser incising density from 2,500 holes/m^2 to 7,500 holes/m^2 did not influence significantly on reducing the m.c. gradient, incising density of 2,500 holes/m^2 was judged sufficient to reduce the gradient of m.c. in the steam injection and microwave drying. Laser incising and microwave heating also helped on reducing checks of dried Japanese larch lumber.